ROULETTE AT MONTE CARLO.

La Loi des petits Nombres. By M. Charles Henry. Pp. xiv+71. (Paris: Laboratoire d'Énergetique d'Ernest Solway, 1908.) Price 4 francs.

THE question discussed by the author may be given in his own words:—

"Est-il possible de prévoir une loi de séquence plus ou moins fragmentaire dans les phénomènes fortuits comme les arrivés de la rouge et de la noire à la roulette?"

He considers that the theory of probabilities is only verified in practice when the number of throws of the ball is indefinitely great, and that new principles are required when the period of play is short. He takes what he terms a psycho-physical point of view, and bases his researches on the ultimate vibrations of particles and the musical interval, the fifth—the ratio 3 : 2. He adopts the latter as governing the sequences at roulette without giving any scientific reason whatever.

It is difficult to take the author seriously, but as he pretends in chapter iv. of the work to give rules of play which will enable a player to win at Monte Carlo, it is necessary to inform the reader that the system of M. Henry is not based upon scientific truth, and can have no effect upon his winning or losing. It still remains true that the construction of the Monte Carlo roulette table gives an advantage to the bank, which, roughly, may be stated to be 1·35 per cent. on the even chances and 2·7 per cent. on the longer chances. The percentage refers to all the money placed upon the table that was originally in possession of one of the players. Should a player stake five francs on one of the even chances, the piece becomes immediately depreciated in value so as to be only worth four francs ninety-three centimes. Placed anywhere else on the table it is worth but four francs eighty-six centimes. If the stake be left upon the table for another coup, with or without previous winnings, a like depreciation takes place, and it is the sum of all these depreciations which in the long run constitutes the profit of the bank.

Statistics show that each table earns about 400*l.* per diem on the average. This shows that the amount staked at each table is about 20,000*l.* per diem. The nine tables in use during the winter months thus earn about 3600*l.* per diem, and the amount staked probably reaches the large figure of 180,000*l.* per diem. It may be regarded as certain that a large majority of the players leave off losers. Of these, certain individuals lose a small sum which they consider is sufficient to leave in the rooms; others a sum which they had previously determined not to exceed; others sums which are in excess of what they wished to lose. On the other hand, a minority of the players will be winners, but this minority becomes smaller as the average time during which the players remain at the table becomes larger.

Many of the players have probably been winners at some time or other during the play. They determined to become larger winners, with the final result that they were losers. Few players know when to stop the game and to hold their hands when a reasonable sum, reasonable in proportion to the playing capital, has been won. The consequence of a player with a moderate capital thus settling down to play the bank for immoderate winnings is in the long run certain ruin, whether the bank has between one and three per cent. in its favour or not.

The large capital of the bank gives it an advantage over the player, whose capital is relatively small, which is quite separate from the advantage derived from the design of the table.

The influence of capital can be well seen in an ordinary even game of rouge et noire. We may suppose Peter and Paul to be the players, and the stake to be 1*l.* at each coup. It is quite certain, whatever be the capital of each, that after a sufficient number of coups one or other will lose all his capital. Which of the two has the greatest chance of being ruined depends upon the ratio between the capitals. It can be shown that Peter's chance of ruining Paul bears the same ratio to Paul's chance of ruining Peter that Peter's capital bears to Paul's. If Peter's capital be 50*l.* and Paul's 40*l.*, it is 5 to 4 that Peter ultimately ruins Paul. The circumstance that the game, if continued long enough, will inevitably lead to the ruin of one of the players may seem surprising to one who has not given the subject special attention. There is a popular fallacy that in the long run Peter and Paul will win very nearly the same number of coups. The fact is that in the result of a large number of coups the ratio of the numbers of coups won by the players approaches unity, but that the difference between these numbers has a tendency to increase beyond any limit. Great as is the advantage of a large capital, it cannot be inferred that the bankers at roulette could afford to play with tables not constructed to their advantage, because then there would be nothing to hinder a combination of capitalists from placing themselves on more than even terms with the bank. So great is the advantage of the bankers due to their large capital that, failing a combination against them, they could afford to play with a table constructed against themselves and in favour of the players.

If the respective capitals of the bank and of a player be known, it is not difficult to design a table which will place the two sides on an exact equality as regards play on the even chances for an unlimited time. When the bank has practically an unlimited number of stakes the solution is very simple, and may be stated as follows:—If the player possess a certain number of stakes, he should be able, from the construction of the roulette, to win on the average a majority out of four times that number of coups. A player with fifty stakes should be able to win 101 coups out of 200. In this case the roulette should have one zero and 100 numbers, and the zero should be in favour of the player. On the existing roulette tables a player with nineteen stakes and the zero in his favour would be on even terms with the bank. There would not be more than an even chance of his final ruin.

The above facts should become known to intending players, so that they may not be misled into thinking that they will make their fortunes by following the advice given in M. Henry's book. That book adds nothing to our knowledge of the probabilities connected with roulette at Monte Carlo.

THE THEORY OF LIGHT.

The Theory of Light: A Treatise on Physical Optics. By Richard C. Maclaurin. In three parts. Part i. Pp. viii+326. (Cambridge: University Press, 1908.) Price 9*s.* net.

THIS is the first instalment of a work on optics arranged on a somewhat novel plan. The volume treats mainly of the propagation of light in homogeneous media, isotropic or crystalline, and of the laws of reflection and refraction at plane boundaries. It is to be followed by a second dealing with the subjects of diffraction, dispersion, aberration, &c.; whilst a concluding volume is to be devoted to the history of optical theory. The method followed is deductive; a medium of the McCullagh type is postulated, and the laws of wave-motion are obtained by an application of the principle of Action. This is practically, of course, the electric theory of light in the form adopted by Larmor. The subsequent developments are naturally almost entirely mathematical, experimental methods being rarely referred to. For this reason the work cannot claim to be, indeed does not profess to be, a complete handbook of the subject; but this is hardly to be regretted, since the English student already has within his reach two masterly expositions from the physical standpoint in Lord Rayleigh's *Encyc. Brit.* article, and in Prof. Schuster's "Optics." A more serious matter is that some recent speculations of importance are ignored. For instance, we read on p. 29:—

"The answer forced upon us by the experimental evidence is that we must regard the [components of white] light as polarised elliptically . . . for an interval of time which is long compared with the period of vibration, but very short compared with the time required to make any impression on the retina or on a photographic plate."

This brings us back to the standpoint of Airy's "Tracts." It is to be hoped that the author will return to this question in his second volume, and that the bearing on it of Rayleigh's and Schuster's work on interference will receive due consideration.

The real value of the book consists in the systematic mathematical discussion of various classes of phenomena from a common point of view. In particular, many readers will be glad to have in an easily accessible form the author's own investigations of the effect of a thin transition layer in the phenomena of ordinary and crystalline reflection and refraction, and metallic reflection. Regard being had to the point of view, the style is clear and attractive, and the reader will appreciate the numerous excellent graphical representations of the somewhat complicated theoretical results.

In a lively introductory chapter the author discusses the methods and aims of science, the object being apparently to anticipate criticisms which might be directed against the special theoretical basis which he has adopted for his exposition. This discussion is pleasant reading enough, but it is to be hoped that future writers on mathematical physics will not always think it necessary to begin in this way. From the student's point of view the procedure has this disadvantage, that he may find the introduction much harder than the book, and perhaps even not intelligible until he has read the book. In the present instance the opening sentence tells us that "the first question in the catechism of every physicist" should be "what is the chief end of science?" The author's own reply to this question is interesting, and has the present writer's sympathy, but one cannot help wondering what degree of uniformity would be found among the answers which would have been given by, say, Archimedes, Galileo, Newton, Pascal, Laplace, Young, Maxwell, Kelvin. Fortunately history shows that the progress of science is not really conditional on the correct resolution of so formidable a question, any more than art has ever stood still for want of a definitive reply to the other secular question, what constitutes the Beautiful?

The remaining volumes will be looked forward to with interest, and the historical section in particular should prove of great value. H. L.

GEOLOGICAL EPITOMES.

Die Alpen. By Dr. Fritz Machaček. Pp. iv+146. (Leipzig: Quelle and Mayer, 1908.) Price 1.25 marks.

Eiszeit und Urgeschichte des Menschen. By Prof. Hans Pohlig. Pp. viii+142. (Leipzig: Quelle and Mayer, 1907.) Price 1.25 marks.

THESE two books, bound in cloth and convenient for the pocket, are members of Dr. Paul Herre's series entitled "Wissenschaft und Bildung." They are printed in the older German type, presumably to give them a popular and untechnical aspect; and their cheapness prevents their half-tone illustrations from being more than suggestive. But the text is by no means of the "nature-study" order, or merely intended to lead a young reader on to better things; it is rather a summary of the results of a wide range of specialised research.

Dr. Machaček in his volume compares the views of various authors on the structure of the eastern and the western Alps, and discusses the origin of the present surface-relief. He accepts the theory of glacial erosion for the "Zungenbecken" of the North Italian lakes as a logical outcome of observations on the deepening of the main glaciated valleys further up among the Alps; and he attributes the rich variety of pictorial features (p. 56) in the central chain to the denuding activities of the Ice-age. Surely no one can nowadays deny the efficacy of "frost-nibbling" in producing crags and *cirques* and wild *arêtes*, when combined with the presence of glaciers, which carry off the débris from the scene of severest action. Nor can the modification in form of the original valleys excavated by streams be ascribed to anything but the